1. ІННОВАЦІЙНІ ПРОЦЕСИ В ЕКОНОМІЦІ

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VECTORS OF RESTRUCTURING OF ECONOMIC SYSTEMS IN THE COURSE OF DIGITAL TRANSFORMATIONS*

Leonid Hr. Melnyk[1], Yuliya V. Rozghon[2], Oleksandr V. Kubatko[3], Lyudmila L. Kalinichenko[4], Oleksandr M. Derykolenko[5]

The article reveals the content of digital transformations during the Fourth Industrial Revolution (Industry 4.0). The latter's direction is defined as the formation of cyber-physical systems, which are designed to replace human labour in production processes. The fundamental transformations taking place during Industry 4.0 are analyzed. These include the formation of the Internet of Things; application of artificial intelligence; construction of "smart" network systems at the level of the enterprise, city, and territory; cyberization of the physical world; integration of human cognitive abilities and artificial intelligence; building a circular economy; formation of self-organized systems based on cloud technologies, etc. In the course of digital transformations, there are significant changes in the form and content of socio-economic systems, which affects the ratio of the constituent elements that form these systems. This phenomenon is defined as restructuring. The reasons determining the key areas of restructuring of economic systems in the course of digital transformations are analyzed. These are: changing the nomenclature of goods and services, changing the structure of technological processes, changing the organizational structure of production, changing the structure of production professions, changing the structure of educational processes, changing the material and informational content of production, changing the structure of transport operations, changing the ratio of human and machine operations, changing the regional production structures, changes in the social structure of society.

Keywords: *restructuring, digital transformations, economic system, technological changes, production structure.*

JEL Classification*: G34, P40, O33*

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[1] *Leonid Hr. Melnyk*, Dr. (Economics), Professor,
Professor of Department of Economics, Entrepreneurship and Business Administration,
Director of Research Institute for Development Economics (IDE) at Sumy State University,
e-mail: melnyk@econ.sumdu.edu.ua
ORCID: https://orcid.org/0000-0001-7824-0678

[2] *Yuliya V. Rozghon,* Student of the Department of Economics, Entrepreneurship and Business, Administration,
Sumy State University,
e-mail: yuliia.rozghon@student.sumdu.edu.ua

[3] *Oleksandr V. Kubatko*, Dr. (Economics), Professor,
Associate Professor at the Department of Economics, Entrepreneurship and Business Administration, Sumy State University,
e-mail: okubatko@econ.sumdu.edu.ua
ORCID: https://orcid.org/0000-0001-6396-5772

[4] *Lyudmila L. Kalinichenko*, Dr. (Economics), Professor,
Professor of Department of Economics and Management,
V.N. Karazin Kharkiv National University,
e-mail: l.kalinichenko@karazin.ua
ORCID: https://orcid.org/0000-0001-9847-8448

[5] *Oleksandr M. Derykolenko*, Dr. (Economics), Associate Professor,
Associate Professor at the Department of Economics, Entrepreneurship and Business Administration,
Sumy State University,
e-mail: o.derykolenko@econ.sumdu.edu.ua

Introduction. Digital transformations are becoming increasingly active in the functioning and development of economic systems. Any transformations that occur within economic entities or in the environment of their functioning inevitably lead to a change in the ratio of structural elements of the construction of macro- and microeconomic systems, which in the economic literature is called *restructuring*. The fourth industrial revolution (Industry 4.0) caused unprecedented changes like the development of economic systems. Their main direction is to transfer the tasks of monitoring the functioning and reproduction of production systems to cyber-physical systems, which, as a rule, take the form of the Internet of Things (IoT). The main vector of these processes is related to replacing material objects of labour and means of production by their information counterparts. Because of this, these processes have acquired the name of digital transformations.

Scientific developments. The topic of Industry 4.0 ййfound a response in the works of leading economists. In particular, in the works of K. Schwab (Schwab, 2017; Schwab et al., 2018) formulated the concept of Industry 4.0. The work of K. Skinner analyzes the impact of digital transformations on people (Skinner, 2018). The works (What, 2022; Industry 4.0) characterize the directions of development of the industrial revolution. The authors of the work (What, 2023) characterize the key problem nodes of the phenomenon. And in some works (Osorio de Vargas, 2015; The Industrial, 2019) considered the prospects for developing the key phenomenon of Industry 4.0 – the Internet of Things.

The purpose and objectives of the article. It should be noted that the mentioned works do not pay enough attention to the problems of restructuring economic systems during the Fourth Industrial Revolution. This article is aimed at analyzing these issues.

1. The key content of Industry 4.0

The issue of the Fourth Industrial Revolution gained significant resonance after the speech at the International Environmental Forum in Davos (2016) by Swiss economist Klaus Schwab, one of the main theorists of the Industry 4.0 phenomenon. He himself characterized this phenomenon as *blurring the boundaries between physical, digital and biological spheres* (Schwab, 2016).

For the first time, the concept of the Fourth Industrial Revolution was formulated at the Hannover Exhibition in 2011, at which this phenomenon was defined as introduc*ing cyber-physical systems* into production processes.

The leadership in the Fourth Industrial Revolution was assumed by Germany, which developed the private-state program " Industry 4.0", in the framework of which large German concerns, with the grant support of research by the Federal Government, create fully automated productions in

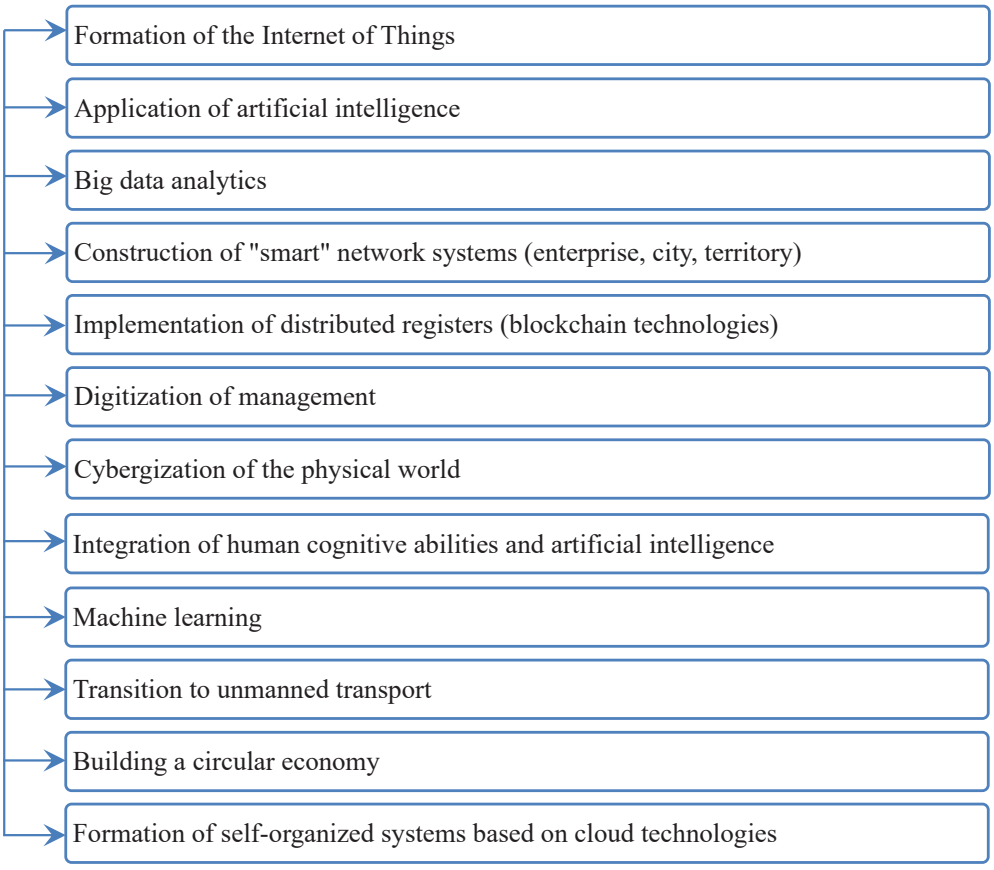

Figure 1 – Changes in socio-economic systems based on Industry 4.0

which lines and products interact with each other and with consumers within the concept of the Internet of Things, due to which the production of individualized products is ensured (Industry 4.0, 2016).

The changes associated with the mentioned industrial revolution are shown in Figure 1.

It is assumed that cyber-physical systems will be combined into a single network with the formation of a kind of local "ecosystems" within it, which functionally serve, say, a certain house, enterprise, or city. As one can see, artificial technical systems are combined into a single global network (system). It is somewhat reminiscent of the biosphere, which unites the ecosystems of the planet's living world.

Based on the analysis of a number of publications (Schwab, 2016; Industry 4.0, 2016), it is possible to formulate the most important functions that the specified cyber-physical systems will have to perform *without human participation*:

– *exchange of information* (a kind of "communication" among themselves) in real-time;

– *control of parameters* of the external environment and one's own;

– *self-activation and stopping* at certain information signals;

– *self-adjustment* to optimal work modes;

– *predicted* (anticipatory, preventive) self-maintenance of systems;

– *interaction with the products produced by them* (if we are talking about production systems);

– *adaptation to new* consumer needs;

– *determination of the equipment* necessary for the production of necessary goods or meeting new needs;

– *self-learning* new work techniques.

2. Processes of Industry 4.0 implementation in economic sectors

Let's try to use concrete examples to analyze the directions of Industry 4.0 implementation in economic sectors. Table 1 examines the implementation processes of Industry 4.0 achievements from the point of view of the possible introduction of the latest technologies for improving production processes and forming appropriate business models that will contribute to the optimization of decision-making processes.

3. Directions of key structural changes during the transition to the digital economy

Significant changes in the form and content of economic systems are necessarily accompanied by their restructuring. Restructuring can be considered as *a change in the parameters affecting the ratio of individual components of economic systems*. Schematically, the key areas of restructuring of economic systems are shown in Figure 2. Briefly describe their content.

Change in the nomenclature of goods and services. When transitioning to a digital economy, the structure of the nomenclature of goods consumed by society changes significantly. This is connected, firstly, with the nature of production processes and, secondly, with the changes that occur in the person himself. The first causes a colossal increase in the role of informational characteristics of products used by consumers in production and everyday life. The second is related to the fact that the need for the consumption of products and services that satisfy the needs of not the biological (material) component of a person but his personal (informational) nature is increasing in the person himself.

The fact that the specified informational characteristics (in particular, form, properties, functions) become leading subjects of work, humanity began to realize when weights began to play an important role: in sizes – fractions of a micron, in forms – configurations of complex geometry, in properties – the ability to work in ultra-high physical conditions, in consumer characteristics – multifunctionality... It was then that goods began to become not material resources and products (bricks, cement, steel, cars) but physical properties and functions: accuracy, strength, speed, speed, reliability, quality, design, and ergonomics provided by these products.

Information products have always existed to one degree or another throughout almost the entire social history of mankind, but only today are they rapidly acquiring the properties of goods. They are actively sold and bought, having their market niches and an established pricing system. Their production and implementation are accompanied by a tough (sometimes very brutal) competitive struggle with inevitable victories and defeats.

These types of products include services:

– education;
– medicine;
– arts;
– cultures;
– show business;
– tourism;
– sports;
– recreation;
– architecture;
– advocacy;
– politics and much more.

Among the types of service activities in the production and distribution of material goods, these types of services become the main groups of the most consumed goods. This is a significant phenomenon. In the person-consumer, the palm of primacy passes from the material essence "bio" to the informational (personal essence) of the person "socio".

Changing the structure of technological processes. Information is increasingly turning into a tool. Today, information systems are an integral part of almost all fixed assets. That information is a key component of computing machines and measuring devices is self-evident and requires no further comment. But information plays an extremely important (and sometimes leading) role in functioning other fixed asset elements: machines,

Table 1 – Directions for the implementation of Industry 4.0 in sectors of the economy

Key tools of new technologies	Examples of technology application
Agriculture	
– Artificial intelligence (AI) helps farmers monitor crops in real time and quickly react to changes in the soil, such as moisture and fertilizer content. – Using AI for irrigation and pest control eliminates the need for manual labour and reduces the use of potentially harmful chemicals. – Machine learning robots can help care for animals by replacing routine human labour.	– Agribot uses computer vision and machine learning to recognize plants, diagnose diseases, detect pests and optimize irrigation. (AgriRobot, 2023)
Industry	
– The Internet of Things allows you to automate production processes, which reduces the risk of errors and increases productivity. – Blockchain ensures process security and data protection. – Machine learning helps increase production efficiency by replacing human physical labour with automation. – The use of AI allows to reduction costs arising in the production process.	– "IBM Watson Visual Recognition" – a product that allows to automate packaging inspection (StudyGyaan, 2020) – Predictions – This application uses data analytics and machine learning to predict failures and repair work in industrial systems. – It allows you to reduce unplanned equipment downtime and optimize resources (Predictronics, 2023) – "C3.AI" – combines artificial intelligence and data analytics to optimize production processes, forecast demand, reduce energy consumption and identify problems in production (C3 AI, 2023)
Logistics	
– The Internet of Things (IoT) provides the identification of objects in logistics processes and, as a result, more incredible speed and coherence of the process. – AI can monitor the quality of perishable products during transport. This helps to reduce costs for damaged goods and ensure product quality for the consumer. – The ability to monitor the vehicle fleet in transport logistics, thanks to IoT, reduces machine downtime. This is very relevant for small companies that have relatively small fleets. The GPS system, which displays all public transport and taxis on the routes, allows you to reduce traffic.	– "Valerann" is an Israeli-British product that works on the GPS system. Thanks to this, you can track road traffic and follow the schedule of public transport. (Valerann, 2023) – ClearMetal is a product that uses data analytics to improve supply chain forecasting and management. It allows identifying problems and risks in supplies and provides more accurate forecasting (Bevor, 2023).
Financial activity	
– Blockchain technologies ensure the safety of financial transactions. – AI helps analyze financial reports, develop investment strategies and make optimal decisions. – The latest technologies allow cooperation with clients in different parts of the world. – Industry 4.0 technologies allow the processing of large data sets.	– Wealthfront is an AI-based software for intelligent investment and asset management. The application analyzes the risks and returns of various investment proposals, offers personalized advice and automatically adjusts the portfolio to meet financial goals (Save, 2023). – "Kasisto" is an application that uses artificial intelligence to develop virtual assistants for bank customers. It provides the ability to carry out financial transactions, receive account information and make transfers by voice or chat (Kasisto, 2023).
Energy	
– Applications based on Industry 4.0 technologies allow for more stable and efficient production and energy use. – AI and machine learning are used in the creation of applications that help manage a "smart" home.	– "Grid4C" machine learning for monitoring and forecasting the operation of electrical networks; the device helps identify faults, optimize energy supply and increase system efficiency (Grid4C, 2023). – Google Home/Google Assistant uses artificial intelligence to control various devices and systems in the home, including lighting, heating, security and other functions (A home, 2023). – "Nest" is a product that allows you to control a thermostat that regulates heating and air conditioning; it uses AI to analyze user behaviour and weather data to ensure maximum comfort and energy efficiency (Nest, JS, 2023).

equipment, tools, devices, transport, transmission devices. Even in the maintenance of buildings and structures, the role of information is becoming more and more tangible.

Information systems increasingly provide the necessary mode of functioning (humidity, temperature, air composition and other physical characteristics). In modern means of work, the leading importance of information is due to two reasons: firstly, the fact that it plays a primary role in the performance of production functions; secondly, by the predominant share of its value in the total price of the product, which sometimes reaches 80–90%. In particular, about 70% of the price of a modern automatic washing machine falls on the small electronic unit that controls the operating modes.

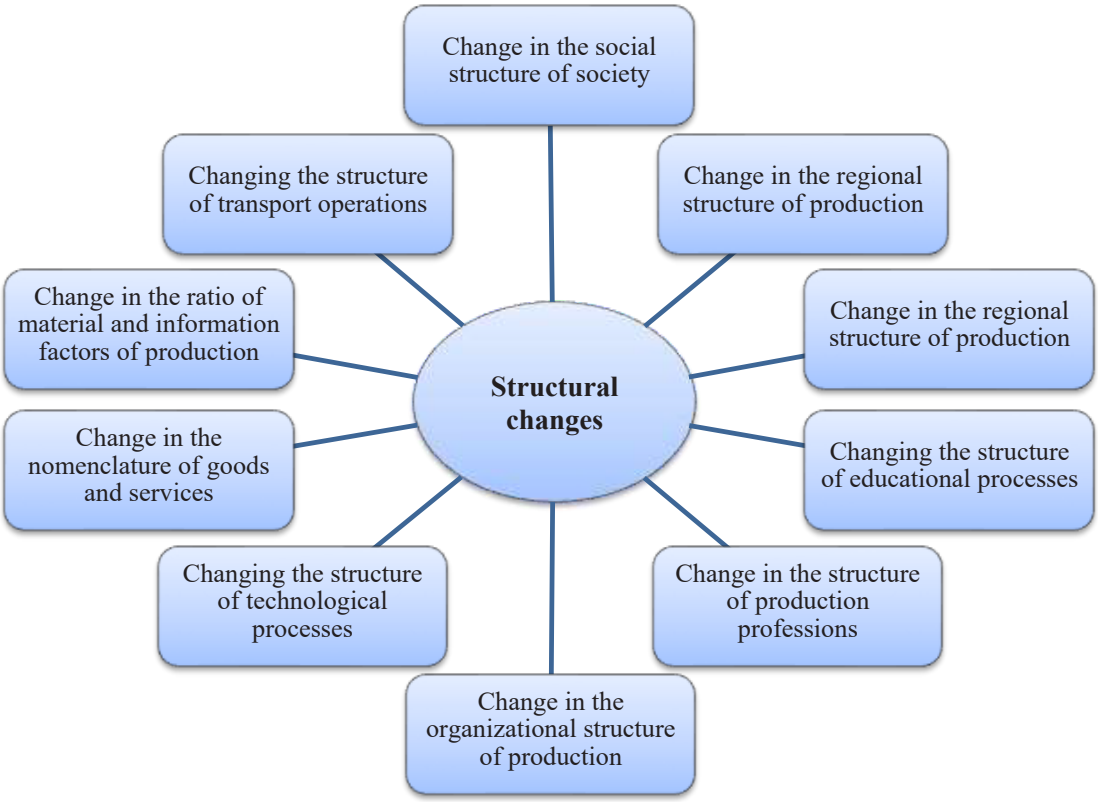

Figure 2. – Key structural changes in the course of digital transformations

Information's role in production is growing even more during the formation of "smart" production systems, the "Internet of Things" and unmanned vehicles.

Future production is expected to undergo significant structural transformations. This is primarily since large economic forms (powerful regional power plants, manufacturing giants, huge processing and enrichment complexes) should be replaced by networks consisting of thousands and even millions of small production units (IT enterprises, mini-energy installations, factories that use 3D printers). They can become a real productive force only by being united in integral network systems.

Change in the structure of production professions. A change in the specifics of production and consumption of products inevitably causes a change in the structure of production professions. Routine operations and physical labour are replaced by operations related to information processing. The processes of production of material products are being replaced by works on the provision of various services, which to a large extent are information goods.

Changing the structure of educational processes. A significant change in the structure of production processes and the professions that provide them require a radical change in the structure of the training of relevant specialists.

Change in the ratio of material and information factors of production. The logic of the development of economic systems shows that in their functioning processes, the role of the information component (compared to the material and energy component) is constantly growing. In particular, the share of labour, material and energy costs for the production and consumption of information in the structure of costs for the implementation of economic processes is constantly growing. In the information component itself, not quantitative but qualitative characteristics are gaining more and more importance: *reliability, adequacy, completeness, relevance, orderliness, timeliness, value, adaptability,* etc.

Change in the structure of transport operations. The indicated direction of restructuring of transport operations is determined by: first, the dematerialization of manufactured products; second, the possibilities of replacing transported goods with their digital counterparts in combination with 3D printing at the place of use; third, the possibilities of online communication of people, which significantly limits the need for their direct contacts; fourthly, the use of GPS technologies, which increases the efficiency of transport operations; fifth, by using sharing relations, which significantly reduces the need for quantitative use of transport units; sixth, the use of unmanned types of transport, which ensures the redistribution of cargo transportation; seventh, by changing the speed of movement of certain types of transport, which changes the structure of redistribution of passenger and cargo transportation between them.

Changing the ratio of human and machine operations. Cyber-physical systems and artificial intelligence, which

are currently entering production, fundamentally change the ratio of human labour and machine operations. At the same time, key communications are significantly changing, including: between a person and a machine; a person with things he uses; machines with machines; a person with another person or group of people.

Change in the regional structure of production. The formation of virtual enterprises allows implementation of the principle of concentration in time of processes deconcentrated in space. Thanks to the creation of production networks, enterprises located in different spatial conditions – often in different corners of the globe – can integrate their activities into single production cycles.

> Similar examples are demonstrated by many well-known companies worldwide, in particular, the multinational corporations "Boeing" and "Aerobus". Another example is the company CISCO – system, which controls the production of about half of the computer equipment in the world. 38 of the world's largest companies in different countries participate in the company's activities. But only two of them belong directly to CISCO itself (Possible, 2012).

Today, on the global market, you can choose as a partner any enterprise that is complementary to you (that is, one that complements your capabilities) in any of the segments of its activity. This enterprise will independently provide its logistics, personnel and technical policy, as well as solve all production and marketing issues for all other segments of its activity.

Change in the social structure of society. The change in the organizational structures of production and consumption of products directly affects the social structure of society. First, there is an intellectualization of society, and an increase in the share of people with a creative activity component. Secondly, one can observe the socialization of society in connection with the emergence of horizontal production networks, the formation of a solidarity economy, and a massive increase in the number of owners of the means of production (computers, alternative energy sources, transport units, 3D printers).

Conclusions. Digital transformations that humanity is currently experiencing are changing the form and content of socio-economic systems. The specified processes inevitably lead to a change in the ratio of structural elements of the construction of macro- and microeconomic systems. This was called restructuring.

One of the most significant phenomena of today, which has an unprecedented civilizational character, is the Fourth Industrial Revolution (Industry 4.0). It aims to introduce cyber-physical systems into production processes to replace the human factor there. The key features of the processes taking place during Industry 4.0 are the formation of the Internet of Things, the application of artificial intelligence; the construction of "smart" network systems at the level of the enterprise, city, and territory; cyberization of the physical world; integration of human cognitive abilities and artificial intelligence; building a circular economy; formation of self-organized systems based on cloud technologies, etc.

These processes lead to changes in the parameters of economic systems that affect the ratio of individual components of economic systems. The key vectors of the restructuring of economic systems in the course of the mentioned processes are: changing the nomenclature of goods and services, changing the structure of technological processes, changing the organizational structure of production, changing the structure of production professions, changing the structure of educational processes, changing the material and informational content of production, changing the structure of transport operations, changing the ratio of human and machine operations, a change in the regional system of production, a change in the social structure of society.

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ВЕКТОРИ РЕСТРУКТУРИЗАЦІЇ ЕКОНОМІЧНИХ СИСТЕМ В ХОДІ ЦИФРОВИХ ТРАНСФОРМАЦІЙ

Леонід Григорович Мельник[1], Юлія Віталіївна Розгон[2], Олександр Васильович Кубатко[3], Людмила Леонідівна Калініченко[4], Олександр Миколайович Дериколенко[5]

Стаття розкриває зміст цифрових трансформацій в ході Четвертої промислової революції (Industry 4.0). Спрямування останньої визначено як явище формування кіберфізичних систем, які покликані замістити працю людини у виробничих процесах. Проаналізовано ключові трансформації, які відбуваються в ході Industry 4.0. До них можна віднести: формування Інтернету речей; застосування штучного інтелекту; побудова «розумних» мережевих систем на рівні підприємства, міста, території; кібергізація фізичного світу; інтеграція когнітивних здатностей людини й штучного інтелекту; побудова циркулярної економіки; формування самоорганізованих систем на основі хмарних технологій та ін. В ході цифрових трансформацій відбуваються значні зміни форми і змісту соціально-економічних систем, що впливає на співвідношення складових елементів, які формують ці системи. Це явище визначається як реструктуризація. Аналізуються причини, які обумовлюють ключові напрями реструктуризації економічних систем в ході цифрових трансформацій. Такими є: зміна номенклатури товарів та послуг, зміна структури технологічних процесів, зміна організаційної структури виробництва, зміна структури виробничих професій, зміна структури освітніх процесів, зміна матеріально-інформаційного змісту виробництва, зміна структури транспортних операцій, зміна співвідношення людських та машинних операцій, зміна регіональної структури виробництва, зміна соціальної структури суспільства.

Ключові слова: *реструктуризація, цифрові трансформації, економічна система, технологічні зміни, структура виробництва.*

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[1] *Мельник Леонід Григорович*, доктор економічних наук, професор, професор кафедри економіки, підприємництва та бізнес-адміністрування Сумського державного університету; директор Науково-дослідного інституту економіки розвитку МОН України та НАН України у складі Сумського державного університету

[2] *Розгон Юлія Віталіївна*, студентка кафедри економіки, підприємництва та бізнес-адміністрування Сумського державного університету

[3] *Кубатко Олександр Васильович*, доктор економічних наук, професор, доцент кафедри економіки, підприємництва та бізнес-адміністрування Сумського державного університету

[4] *Калініченко Людмила Леонідівна*, доктор економічних наук, професор, професор кафедри економіки та менеджменту Харківського національного університету імені В.Н. Каразіна

[5] *Дериколенко Олександр Миколайович*, доктор економічних наук, доцент, доцент кафедри економіки, підприємництва та бізнес-адміністрування Сумського державного університету